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GEOLOGY OF SAN MIGUEL ISLAND SANTA BARBARA COUNTY, CALIFORNIA

BY

CARL ST. J. BREMNER

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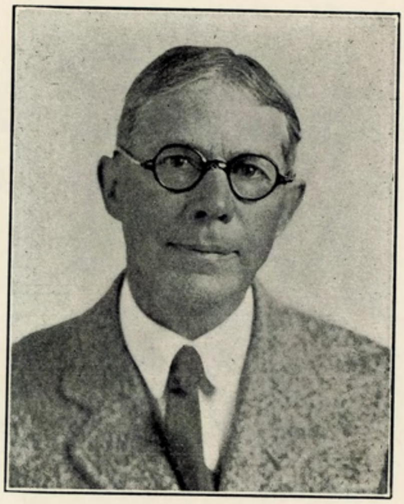

In memory
of
Ralph Hoffmann

Director of the Santa Barbara Museum of Natural History, who lost his life on July 21, 1932, from a fall while in pursuit of botanical studies on this island.

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CONTENTS

INTRODUCTION

The island of San Miguel is the most westerly of a chain of four islands that form the south side of the Santa Barbara Channel. A distant view of these islands readily suggests that they form a geologic unit, and but little imagination is needed to visualize a continuous range in place of the four islands. In fact, if the land were evenly uplifted a little less than 200 feet the islands would be connected in one unit, but there would still be a strait 10 miles in width and over 700 feet deep between the eastern end of the group and the Santa Monica Mountains, of which they structurally form a part. The greatest depth, over 2100 feet (350 fathoms), of the Santa Barbara Channel lies midway between Santa Rosa Island and the mainland.

The Santa Barbara Channel Islands have until recently, been neglected by geologists, probably because an early map showed them to be composed almost entirely of volcanic rocks. It was not until 1927 that work by Kew[2] on Santa Rosa Island disclosed the important rôle played by sedimentary rocks in the stratigraphy of the islands. The early report on the Channel Islands by Yates[3] refers to Anacapa Island, and that of Goodyear[4] and Rand[5] concerned Santa Cruz Island. Kew[6] described the geology of Santa Rosa Island, and Hertlein,[7] in a preliminary report deals with the invertebrate paleontology of Santa Rosa and San Miguel islands. A recent paper by the writer[8] described in detail the geology of Santa Cruz Island.

The writer acknowledges with appreciation the assistance of Mr. R. L. Brooks, the lessee of San Miguel Island; also the technical assistance of Mr. W. H. Corey in the determination of Miocene fossils, and of Messrs. H. L. Driver and W. H. Holman in the determination of foraminifera. Dr. W. S. W. Kew kindly reviewed the manuscript and prepared the plates of fossils. The aerial map of this island was furnished by the Continental Air Map Company, Los Angeles, California.

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[1] Published by permission of G. C. Gester, Chief Geologist, Standard Oil Company of California.

[2] Kew, W. S. W., A Geologic Sketch of Santa Rosa Island: Geol. Soc. America Bull., Vol. 38, pp. 645–654, Dec. 1927.

[3] Yates, L. G., Stray Notes on the Geology of the Channel Islands: Calif. State Min. Bur., 9th An. Rept., pp. 171–174, 1890.

[4] Goodyear, W. A., idem. pp. 139–170, 1890.

[5] Rand, W. W., Preliminary Report on the Geology of Santa Cruz Island, Santa Barbara County, California: Rept. State Miner., California State Min. Bur., Vol. 27, pp. 214–219, April 1931.

[6] Kew, W. S. W., op. cit.

[7] Hertlein, L. G., Preliminary Report on the Paleontology of the Channel Islands: Jour. Paleon., Vol. 2, No. 2, pp. 142-157, June 1928.

[8] Bremner, C. St. J., Geology of Santa Cruz Island: Santa Barbara Mus. Nat. Hist., Occas. Papers No. 1, 1932.

LOCATION AND TOPOGRAPHY

San Miguel Island is the most westerly of the Santa Barbara Channel Islands. It lies about 25 miles south of Point Concepcion and is separated from the most westerly point of Santa Rosa Island by a strait three and one-half miles wide which has a maximum depth of a little more than 100 feet (17 fathoms). The island is roughly triangular in shape, measures about eight miles long and averages about two miles wide, though the maximum width is four miles. The area is about 14,000 acres.

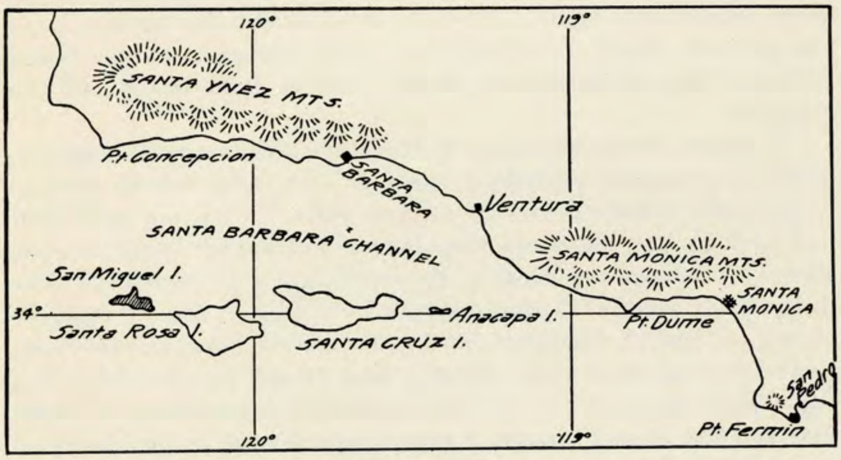

Fig. 1. Map showing the location of the Santa Barbara Channel Islands.

The topography of San Miguel is quite low in contrast to the high rugged peaks and ridges of the other islands of the group and, therefore, it can rarely be seen from the mainland except on a very clear day. Most of the surface of the island is a wave-cut terrace from 400 to 500 feet in elevation, above which rise two rounded hills, one to 850 feet and the other to 861 above sea level. A lower terrace from 20 to 100 feet in elevation borders the south coast, and narrow scattered remnants of the same terrace can be seen on the northwest shore. The island has been eroded but little since the terraces were cut. Two streams heading on the flanks of Green Mountain and flowing northward and southward respectively, have cut deep narrow canyons in the sandstones that underlie the terrace deposits. Another steep narrow canyon heads on the terrace near the ranch house and drains northward to Cuyler Harbor. Willow Canyon, which is in the southeast corner of the island and drains eastward, has cut but a narrow shallow trench through the terrace sands and into the underlying rocks. This stream is prevented from deepening its channel

rapidly by the ridge of hard andesite agglomerate that it crosses near its mouth. The embayment of Cuyler Harbor has been formed where a fault offset the hard ridge of volcanic rocks that forms the northeast coast, and allowed the waves to attack the softer rocks behind.

The island when first visited by Europeans, was covered with a dense growth of brush, such as sumac and manzanita. Cattle and sheep were placed on the island about fifty years ago and allowed to multiply without restriction, with the result that much of the vegetation was destroyed. The strong prevailing winds from the northwest then formed dunes of drifting sand that now cover most of the surface. The drifting sand is gradually filling up Cuyler Harbor to the extent that anchorage is impaired by the huge swells that break inside the harbor during the winter season. It seems very probable that this condition did not exist when Juan Rodriguez Cabrillo, on the first voyage of discovery into these waters, wintered his boats there in 1542.

STRATIGRAPHY

The stratigraphic section of San Miguel Island is composed of Tertiary rocks with the exception of the Pleistocene terrace deposits. More than 10,000 feet of Eocene marine sediments are represented, 1500 feet of Miocene marine sediments and over 2300 feet of Miocene volcanic rocks. The Miocene rocks are confined to the eastern part of the island and the Eocene to the western part.

Eocene Series (Undifferentiated)

The oldest rocks on the island are those referred to the Eocene series and crop out continuously along the shore from Crook Point on the south coast, westward to Point Bennett and thence eastward on the northeast coast almost to Harris Point. They are also seen on the surface at Green Mountain and in a faulted block on the shore of Cuyler Harbor.

The section is composed essentially of massive marine sandstones which alternate with zones of thin-bedded sandstones and mudstones. Some thin beds of fine conglomerate and one thick massive bed of coarse conglomerate occur with the sandstones. The sandstones are either thick-bedded or massively developed, vary in grain from medium to coarse and even assume the character of grits, which in places are finely conglomeratic. Large spherical concretions weather out of the sandstones exposed on the south coast. The color of the sandstones is light to dark gray, weathering to buff. Sandstones comprise about 60 per cent of the entire Eocene strata and occur mostly at the bottom and top of the section.

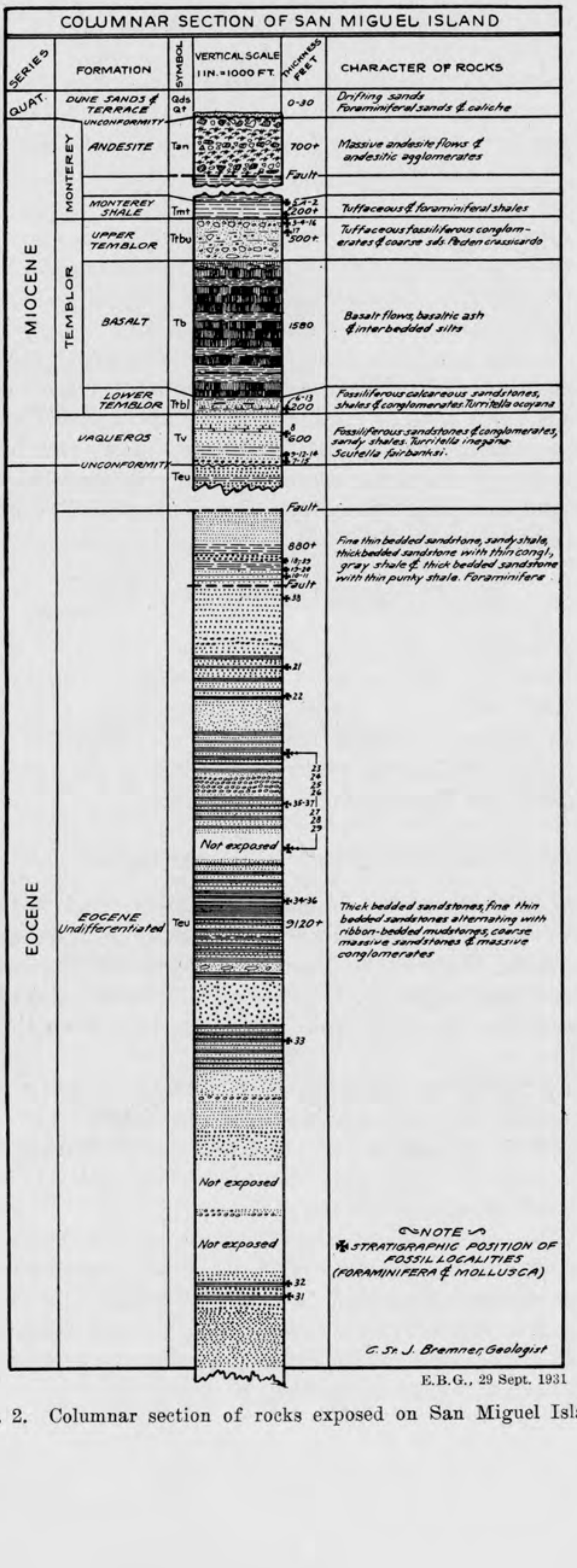

Fig. 2. Columnar section of rocks exposed on San Miguel Island.

The middle part of the section consists mainly of fine-grained, thin-bedded sandstones and mudstones, but thin beds of mudstones are also intercalated with the massive sandstones. The mudstones are

Part of San Miguel Island viewed from Cuyler Harbor, showing the terraced surface of the island and the steeply-dipping Eocene strata on the shore.

Massive Eocene sandstones at Point Bennett, the oldest beds exposed on the island.

dark gray in color and occur usually as laminae about one-half inch thick. They alternate with very fine, light-gray sandstone, giving the section a distinct banded appearance. In other places where the sandstone laminae are absent, the mudstones are uniformly dark and massive.

Thin-bedded Eocene sandstones on the south coast 1½ miles east of Point Bennett.

Massive Eocene conglomerate on the northwest coast opposite Castle Rock.

Basalt faulted against Monterey shale on the south coast near Cardwell Point.

Sand dunes on the upper terrace two miles northwest of Cardwell Point.‘

The conglomerates in the lower part of the section occur in thin beds or lenses and, in general, the pebbles are small, about one-half inch in diameter, and are well-rounded and polished. They are composed of hard dark-colored aphanitic rocks such as chert and chalcedony together with some light-colored quartz and quartzite. On the northwest shore of the island there is a bed of very coarse massive conglomerate that, due to faulting, is repeated in the exposed section three times. This bed is from 200 to 220 feet in thickness and is composed of rounded and polished boulders varying in diameter from three inches up to one foot. These boulders consist of diorite and other granitic types, red and gray felsite porphyry, and quartz. The lithology of this conglomerate is similar to the massive conglomerate that occurs in the Domengine formation (upper Eocene) of Santa Cruz Island.

If these two conglomerates can be correlated, then the 2200 feet of thin-bedded sandstones and mudstones under the conglomerate on San Miguel Island would correspond with the Domengine lower shale member and lower sandstone member of Santa Cruz Island, and the massive sandstone below the mudstones of San Miguel would correspond to the Martinez formation of Santa Cruz. The foraminifera in samples collected from the mudstones below the conglomerate on the northwest coast of San Miguel and from approximately the same horizon on the south coast, have affinities, according to H. L. Driver and W. H. Holman, with the foraminiferal faunas of the Domengine lower shale member of Santa Cruz Island.

The uppermost part of the Eocene section occurs in a block between two faults and is exposed on the shore of Cuyler Harbor. About 880 feet of strata are exposed which consist of fine thin-bedded sandstones, gray sandy shale and light-gray clay shale that breaks with a conchoidal fracture, and thick sandstone beds separated by very thin grayish bands of punky shale. The shale beds in these strata contain an abundance of foraminifera. A thin bed of conglomerate in thick-bedded sandstone occurs between the two shale zones and contains finely comminuted fragments of oyster shells and other molluscs, but no other megascopic fossils were found. The foraminifera in the shale beds are similar to those in the upper shale member of the Domengine of Santa Cruz Island.

The entire Eocene section shows a striking paucity of molluscan fossils. A fragment of *Solen* found in sandstone opposite Castle Rock, and the comminuted shells in the conglomerate on the shore of Cuyler Harbor, are the only Eocene molluscs noted. Foraminifera are present in most of the argillaceous beds though not abundant, and the arenaceous forms predominate over the calcareous types.

The following is the stratigraphic section of Eocene rocks exposed on San Miguel Island:

Section at East End of Cuyler Harbor

(fault)	*Feet*	
Fine thin-bedded sandstone	410	
Sandy shale	110	
Thick-bedded medium-grained sandstone with thin bed of fine conglomerate containing comminuted shells	80	
Light-gray shale	110	
Thick-bedded sandstone with thin beds of grayish punky shale	170	
(fault) ... Sub-total		880

Section Along Northwest Coast

(fault)		
Thick sandstones with lenses of conglomerate at bottom	690	
Not exposed (thin sandstones and mudstones?)	700	
Massive coarse sandstones and grits, finely conglomeratic, with a few six-inch beds of mudstone	320	
Fine thin-bedded sandstones and mudstones	240	
Thick sandstone	10	
Thin gray sandstone and mudstone	250	
Very massive coarse conglomerate with polished boulders of diorite and felsite porphyry	430	
Massive sandstone	20	
Not exposed (thin-bedded sandstone and mudstone?)	310	
Thick sandstone and thin mudstone	120	
Thin-bedded sandstone and mudstone	230	
Laminated mudstone	350	
Laminated sandstone and mudstone	530	
Massive concretionary sandstone	70	
Thin-bedded sandstone and mudstone	110	
Massive sandstone	530	
Thin-bedded sandstone and mudstone	520	
Massive sandstone with fine conglomerate at bottom	360	
Thin-bedded sandstone	350	
Massive sandstone	350	
Not exposed	570	
Coarse sandstone and conglomerate	100	
Not exposed	640	
Thick sandstone with thin bands of mudstone	410	
Massive sandstone	710	
(Base not exposed)	...	
Sub-total ...		8,920
Total ...		9,800

Miocene Series

VAQUEROS FORMATION (LOWER MIOCENE)

The oldest sediments of the Miocene series belong to the Vaqueros formation, and form a continuous sequence with the overlying Temblor formation, from which it is separated only on paleontologic evidence.

The Vaqueros formation rests upon the underlying Eocene rocks with a slight angular unconformity. This unconformity is exposed for a distance of 200 yards in the short canyons that cut the upper bluff opposite Crook Point on the south coast. The actual contact shows a gentle undulating surface of erosion in the massive Eocene sandstones upon which the fine, silty conglomerate of the Vaqueros was deposited. The discordance in dip is very little, probably under five degrees at this point, but the trace of the contact perceptibly crosses the strike of the older rocks. Over 800 feet of the uppermost Eocene strata that are exposed at Cuyler Harbor have been apparently overlapped, as they do not appear on the south coast.

The Vaqueros formation measures 600 feet in thickness and consists of interbedded thin-bedded fine conglomerates, sandstones, and shale. The conglomerates are composed of small pebbles of quartz, hard, dark-colored chert and other aphanitic rocks, well-rounded, polished, and not exceeding one-half inch in diameter. The beds range from a few inches up to four feet in thickness and in places are fossiliferous. The sandstones are medium to fine-grained, weather brownish in color, and in places are calcareous or contain very thin limestone partings. The calcareous beds are also fossiliferous. The shales are sandy or silty, weather olive-gray, and are interbedded with the sandstones.

The following section is exposed in the upper part of the canyon that empties at Crook Point and represents the lowermost beds of the Vaqueros formation:

	Feet
Sandy shale with thin calcareous beds carrying *Spondylus perrini* and *Pecten miguelensis*	40
Medium-grained brown sandstone	20
Fine conglomerate with well-rounded pebbles	4
Sandy shale calcareous in places, carrying *Scutella fairbanksi* cf. *santanensis*.	35
Fine muddy sandstone, conglomeratic at base	25
Total	124

unconformity

Massive sandstone and thin mudstone, Eocene.

Fossils from beds referred to the Vaqueros formation. (See map Pl. 2 for localities.)

	7	8	9	12	14	15
Echinoidea						
Scutella fairbanksi cf. santanensis Kew	x		x			x
Scutella cf. vaquerosensis Kew				x		
Pelecypoda						
Pecten miguelensis Arnold s.s.	x					
Pecten miguelensis (Arnold) submiguelensis Loel & Corey					x	

	7	8	9	12	14	15
Spisula catilliformis (Pack)		x				
Spondylus perrini Wiedey					x	
Tivela? cf. inezana Conrad						x
Gastropoda						
Natica cf. reclusiana Deshayes		x				
Rapana vaquerosensis Arnold	x					
Rapana vaquerosensis imperialis (Hertlein & Jordan)		x				
Turritella inezana Conrad s.s.			x	x		
Turritella temblorensis Wiedey		x				
Turritella tritschi Hertlein				x		
Bryozoa						
sp.?	x					
Arthropoda						
Balanus sp.		x				

The forms *Scutella fairbanksi* cf. *santanensis* Kew, *Scutella vaquerosensis* Kew, and *Turritella inezana* Conrad are diagnostic for the Vaqueros formation, but *Pecten miguelensis* Arnold, *Rapana vaquerosensis* Arnold, and *Turritella tritschi* Hertlein are also found in what Corey regards as a transition zone between the Vaqueros and the true Temblor faunas.

TEMBLOR FORMATION (MIDDLE MIOCENE)

The rocks comprising the Temblor formation may be divided into three parts, (1) a lower member of marine clastics, (2) a middle member of volcanics, and (3) an upper member of marine clastics containing tuff.

Fossils from beds referred to the Temblor formation. (See map Pl. 2 for localities.)

	Lower Member		*Upper Member*			
	6	13	3	4	16	17
Pelecypoda						
Arca n. sp.?	x	x				
Ostrea vespertina Conrad	x					
Ostrea sp.					x	
Pecten cf. andersoni Arnold						x
Pecten crassicardo Conrad	x		x	x	x	
Pecten miguelensis Arnold s.s.		x				
Gastropoda						
Turritella ocoyana Conrad	x	x				
Turritella ocoyana (Conrad) bösei (Hertlein & Jordan)	x	x				
Arthropoda						
Balanus sp.		x				

The sandstone bed underlying the oyster beds that contain *Turritella ocoyana* Conrad was arbitrarily chosen for the division between the Vaqueros and Temblor formations, although this bed might be in the Vaqueros-Temblor transition zone and not true Temblor. The upper member which contains *Pecten crassicardo* Conrad and *Pecten andersoni* Arnold is probably true Temblor.

Lower member.—The lower member of the Temblor formation represents a continuation of the Vaqueros sedimentation under the same conditions, and the lithology is, therefore, essentially the same. The beds are exposed on the south coast east of Crook Point, and in the bluff between the lower and upper terraces. They consist of thin fine conglomerates, calcareous sandstones, and olive-gray shales. The member is about 200 feet thick and like the Vaqueros, is fossiliferous.

INCOMPLETE SECTION OF LOWER MEMBER EXPOSED ALONG SOUTH COAST EAST OF CROOK POINT

	Feet
Platy tuffaceous shale (in basalt member)	200(?)
Bed composed mainly of *Ostrea vespertina*	2
Sandstone with calcareous nodules	15
Brown silty sand	15
Calcareous sandstone with *Turritella ocoyana*	2
Sandy clay with abundance of *Ostrea vespertina*	10
Sandy clay with calcareous nodules	4
Olive-gray silty shale	2
Oyster bed	2
Hard brown calcareous sandstone with calcareous fucoids	20

Basalt member.—The basalt member comprises a series of volcanic and clastic rocks, 1580 feet in thickness, that overlies the lower member of the Temblor formation. It is apparently conformable with the lower member but at one locality it seems to overlap the Vaqueros formation. The relationships at this point, however, are not clear. This overlap might be due to a slight unconformity between the basalt member and the lower member of the Temblor. This possibility is supported by Hertlein's[9] discovery of a worn fragment of *Turritella inezana* in conglomerate interbedded in the andesitic series that overlies the Monterey shale.

The basalt member consists of an alternation of dark-brown silts, basaltic ash and tuff, with thin flows of basalt in the upper part. The brown silts were evidently derived from the contemporaneous erosion of the volcanic material. The relation of the basalt with the associated brown silts strongly suggests that much of the basaltic material was either extruded under the sea in shallow water, or were flows extending from the land into the sea. These beds are exposed on the beach,

[9] Verbal communication.

in the upper bluff in the southeast corner of the island, and also near Cuyler Harbor where they are faulted against the Eocene rocks.

Upper member.—The upper member of the Temblor formation consists of tuffaceous conglomerates and sandstones with much fragmental volcanic material. These beds are conformable and gradational with the underlying basaltic member. The fragmental volcanic material, however, is more acidic than the basalt. The beds are exposed only in Willow Canyon and its tributaries. This member measures 500 feet in thickness but it is probable that the complete section is not exposed due to faulting.

Fossils were found at three localities with *Pecten crassicardo* Conrad the most common, and *Pecten andersoni* Arnold occurring at one locality. The member was referred to the Temblor formation on the occurrence of *Pecten andersoni.*

MONTEREY FORMATION (UPPER MIOCENE)

Shale member.—The Monterey shale is the youngest sedimentary member of the Miocene that occurs on the island, and lies conformably upon the upper member of the Temblor formation. It is exposed in Willow Canyon in normal contact with the tuffaceous conglomerate, and also on the south coast near Cardwell Point, faulted against the basalt.

The beds consist of soft yellowish tuffaceous to punky thin-bedded shale, with some fine soft sandstones in the lower part. *Pecten* cf. *peckhami* Gabb was found at two localities in Willow Canyon. The abundant foraminiferal fauna (localities 1, 2, and 5) was referred by H. L. Driver and W. H. Holman to the Monterey (uppermost part of *Valvulineria californica* zone). The shale exposure in Willow Canyon lies in a narrow syncline along a fault. Only 200 feet of beds are visible which thickness undoubtedly represents only a part of the complete section.

Andesite member.—A series of volcanic rocks that form bold cliffs on the northeast shore of the island are the youngest of the Miocene rocks that are found on the island. These consist of very hard coarse reddish-colored andesitic agglomerates with grayish-yellow and grayish-white andesites and felsites. They are so massive that their attitude is very difficult to determine, but in general the dip appears to be southwestwardly toward the older formations against which they are undoubtedly faulted. The existence and location of the fault cannot be determined accurately because the contact of the andesite with all other rocks is covered by sand dunes. The exposed part of the andesitic member is only 700 feet thick, but the complete section is probably much greater.

The sequence of the older Miocene formations is readily established by a completely exposed section, so that the stratigraphic position of the andesite above the Monterey shale can be logically inferred. It is impossible to determine, however, if any other rocks lie between them.

A part of the upper Miocene section on Santa Rosa Island consists of a thin section of Monterey shale followed by a thick series of massive sandstones which in their upper part contain beds of tuff and andesitic agglomerate. These agglomerates appear to be the correlative of the andesitic series of San Miguel. The sandstone series with the associated agglomerates on Santa Rosa, have been referred to the Santa Margarita formation by Kew.[10] Foraminifera recently collected from a bed of shale intercalated with the tuffs, were determined by H. L. Driver to belong in the upper part of the Monterey. The andesitic member of San Miguel Island has, on this evidence, been included in the Monterey, but it is logical to assume that it might include a part of the Santa Margarita formation (upper Miocene).

Quaternary Series

TERRACE DEPOSITS (PLEISTOCENE)

Deposits of unconsolidated sand from 10 feet to 30 feet in thickness cover the wave-cut terraces that extend over most of the area of the island. The sands on the upper terrace contain foraminifera, shark teeth, whale bones, and comminuted shells. These beds might be in part the correlative of the beds of coquina at the east end of Santa Cruz Island which are referred to the San Pedro formation. Irregular patches of soft white porous caliche, derived from the leaching of the calcium carbonate of shell fragments, are found on the surface of the terrace.

SAND DUNES (RECENT)

Sand dunes derived from the erosion of the terrace deposits and from the beaches on the northwest shore, are swept across the island by the strong prevailing wind from the northwest (see Pl. 1). The wind, blowing down the heads of the stream courses at the top of the upper bluff on the south side of the island, forms veritable rivers of sand that flow down the slope and across the lower terrace to the water's edge.

The preëxistant vegetation that was killed and covered by the dunes, apparently left holes that were filled by sand cemented with lime, thus roughly preserving the original forms. On removal of the dunes by the wind, curious white pipes are left standing above the surface.

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[10] Kew, W. S. W., op. cit.

Intrusive Rocks

Intrusive rocks are quite rare on the island. Two dikes of basalt not over 30 feet wide, have intruded the Eocene rocks on the north-

View southwestward toward Crook Point, showing bedded silts in the Miocene basalt member, the lower wave-cut terrace, and the sand blown from the upper terrace down upon the lower terrace and out to sea.

Sand cemented with calcium carbonate, preserving the forms of roots and stumps of vegetation destroyed in the past century, one mile northwest of ranch house.

west coast. A small outcrop of dark perlite with abundant spherules, which occurs just below the Vaqueros contact on the south coast, also appears to be intrusive. Castle Rock, the sharp-pointed rock 145 feet high that lies one-half mile off the northwest coast, viewed through

binoculars, shows the massive character and jointing more or less common to the felsite intrusives, and appears to be a volcanic plug. The rock probably belongs to the same period of volcanic activity as the andesitic extrusives.

Stratigraphic Correlation of the Santa Barbara Channel Islands

The correlation of the various stratigraphic units of the channel islands, based upon lithologic similarity and fauna, is relatively certain for the Miocene, but for the Eocene, only a more general correla-

Stratigraphic Correlation of the Santa Barbara Channel Islands

	ANACAPA	SANTA CRUZ	SANTA ROSA	SAN MIGUEL
Pleistocene	Terrace	Terrace	Terrace	Terrace
		San Pedro?		*San Pedro?*
Miocene			Rhyolitic and andesitic ash and agglomerate, thin sandstone with schist fragments	Andesite and andesitic agglomerate
			Massive sandstone	
		Silicious shale	*Silicious shale* and *sandstone*	*Silicious shale* *Tuffaceous conglomerate*
		Andesite		
	Basalt	Basalt	Basaltic muds and ash	Basaltic muds and ash
		Rhyolite		
		Schist conglomerate		
		Temblor	*Temblor*	*Temblor*
			Vaqueros	*Vaqueros*
Eocene		*Domengine*	Eocene (undifferentiated)	Eocene (undifferentiated)
		Martinez		
Jurassic? and Triassic?		Diorite and Metamorphics		

(Fossiliferous beds in italics)

tion can be made. The Eocene of Santa Cruz Island contains a diagnostic fauna of both mollusca and foraminifera, but on Santa Rosa and San Miguel islands, only foraminifera were found in the strata below the Miocene. The shales and mudstones in the upper and middle part of the San Miguel section contain foraminifera that are similar to the faunas of the upper shale and lower shale members of the Domengine, respective, of Santa Cruz. This correlation is strengthened by the presence of a characteristic massive conglomerate in both sections. Foraminifera obtained from the lower part of the shales in the Wreck Canyon section on Santa Rosa, show affinities with the fauna of the Domengine upper shale member of Santa Cruz. The massive sandstones at South Point on Santa Rosa Island, called Chico (upper Cretaceous) by Kew, have the same characteristics as those at the west end of San Miguel. These sandstones are now known to be a part of the Domengine formation.

Anacapa Island, although not visited by the writer, is composed of dark massive rocks that dip northward about 20 degrees. These are identical in appearance with the basalts on the eastern end of Santa Cruz, and are undoubtedly continuous with them. These rocks were briefly described in a short paper by Yates[11] in 1890.

STRUCTURE

General features.—The island of San Miguel marks approximately the eastern end of a range of mountains that extends westerly from the Santa Monica Mountains of the mainland. The Santa Barbara Channel Islands are characterized by a westerly trend of their structural lines, parallel with the Santa Ynez Mountains, in contrast with the northwesterly structural trend of the mainland north of Point Concepcion. San Miguel, however, shows a stronger influence of the northwesterly trend in contrast with the other islands.

The entire section of strata on San Miguel, from the west end to the northeast coast, strikes uniformly from N. 40° W. to N. 60° W., and dips homoclinally northeastward from 45 to 20 degrees, with the exception of the volcanic rocks on the northeast coast, which, due to faulting, dip gently southwestward. No folds occur other than the small syncline developed between two faults near the east end of the island, in which lies the Monterey shale.

Faults.—Faults are fairly numerous and fall mainly into two systems that strike approximately N. 40° W. and N. 70° W. respectively. A few small faults near the west end of the island strike northeasterly. The two largest faults were named by the writer for convenience, the Cardwell fault and the Simonton fault.

[11] Yates, L. G., op. cit.

The Cardwell fault forms the southwestern contact of the andesitic series and the older sedimentary formations from Cardwell Point to Harris Point. The location as shown on the geological map is approximate, because the fault contact is everywhere covered by sand. The existence of a fault at this place is the only logical explanation for the stratigraphic and structural relations that occur. The movement which dropped the andesite on the northeast side of the fault, must have been considerable, as some of the upper Temblor conglomerates and most of the Monterey shale have been cut out, as well as any additional thickness of the andesitic series that might be present beneath the exposed 700 feet. The minimum throw of the fault, therefore, is 1400 feet. An offset in the Cardwell fault appears to have been responsible for the development of Cuyler Harbor.

The Simonton fault branches from the Cardwell fault, passes south of Cuyler Harbor and extends into the sea at the west end of Simonton Cove. The fault plane which is visible in the canyon on the road from the harbor to the ranch house, dips 80 degrees south, and the basaltic series is downthrown on the south side of the fault against the upper Eocene strata. The minimum stratigraphic throw of the fault at this point is 1700 feet. The trace of this fault westward is hidden by the cover of wind-blown sand, but its location on the northwest shore can be determined by the duplication of the beds in the section. The duplication or stratigraphic separation on the coast is 2200 feet, which is equivalent to a throw of 3800 feet on the fault.

EXPLANATION OF PLATE 2

TYPICAL FOSSILS OF SAN MIGUEL ISLAND

FIG. 1. *Ostrea vespertina* (Conrad) var. *loeli* (Hertlein) Loel and Corey. Referred to as *Ostrea weideyi* by Hertlein in Journ. Pal., Vol. II, No. 2, June, 1928. Specimen No. 32.1 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 6 (Bremner) San Miguel Island; lower member of Temblor formation. Altitude of specimen 94 mm.

FIG. 2. *Scutella fairbanksi* Arnold cf. *santanensis* Kew, Specimen No. 32.2 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 7 (Bremner) San Miguel Island; Vaqueros formation. Width of specimen 37.3 mm.

FIG. 3. *Ostrea vespertina* (Conrad) var. *loeli* (Hertlein) Loel and Corey. Specimen No. 32.3 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 6 (Bremner) San Miguel Island; lower member of Temblor formation. Altitude of specimen 85 mm.

FIG. 4. *Rapana vaquerosensis* (Arnold) var. *imperialis* (Hertlein and Jordan) Loel and Corey. Specimen No. 32.4 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 7 (Bremner) San Miguel Island; Vaqueros formation. Altitude of specimen 74 mm.

FIG. 5. *Rapana vaquerosensis* Arnold. Specimen No. 32.5 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 7 (Bremner) San Miguel Island; Vaqueros formation. Altitude of specimen 39 mm.

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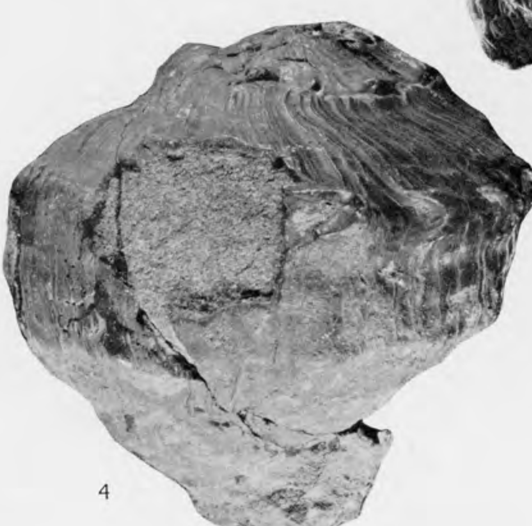

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EXPLANATION OF PLATE 3

TYPICAL FOSSILS OF SAN MIGUEL ISLAND

FIG. 1. *Pecten miguelensis* Arnold s.s. Specimen No. 32.6 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 16 (Bremner) San Miguel Island; upper member of Temblor formation. Altitude of specimen 120 mm.

FIG. 2. *Pecten crassicardo* Conrad. Specimen No. 32.7 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 16 (Bremner) San Miguel Island; upper member Temblor formation. Altitude of specimen 75 mm.

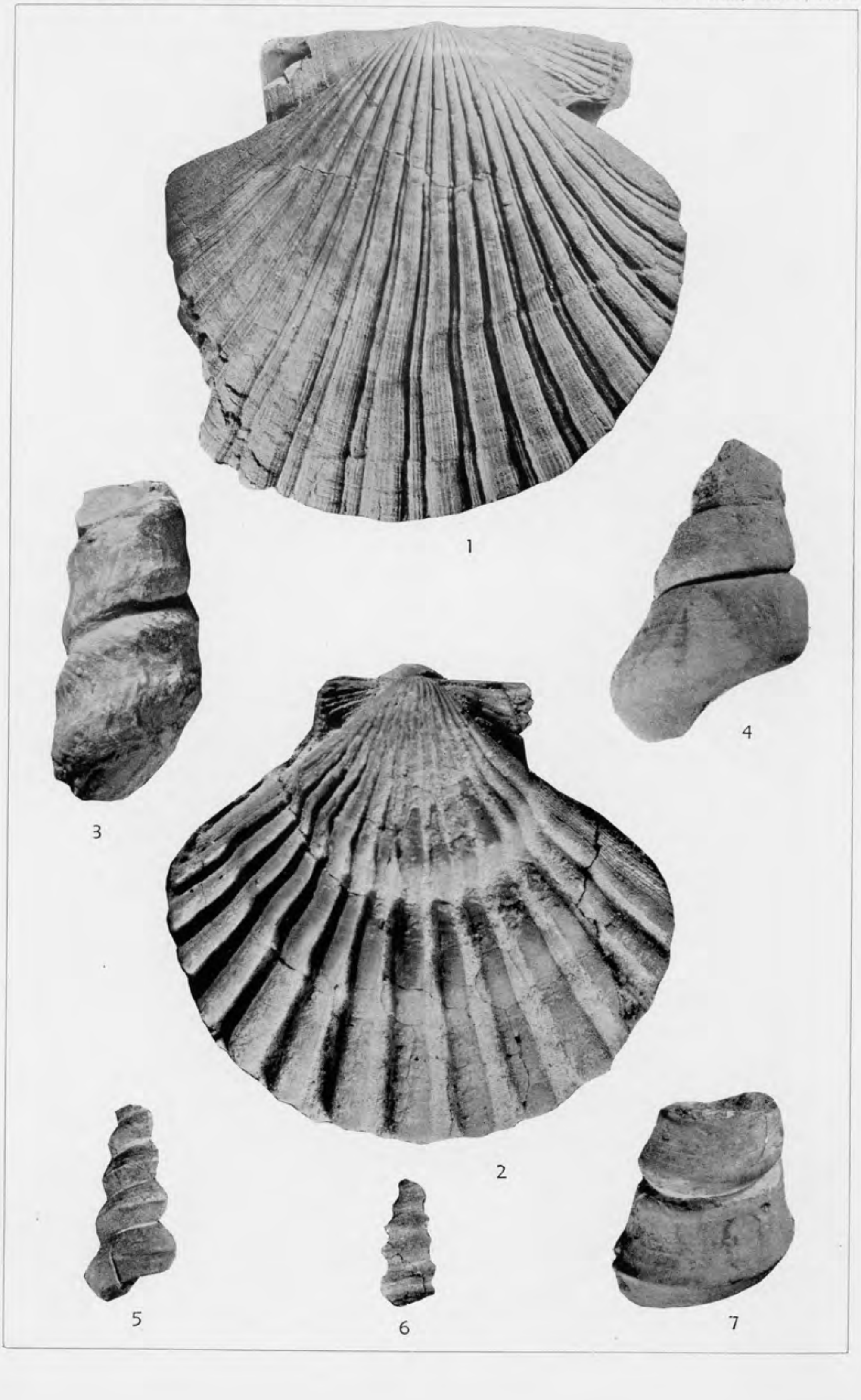
FIG. 3. *Turritella ineziana* Conrad s.s. Specimen No. 32.8 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 9 (Bremner) San Miguel Island; Vaqueros formation.

FIG. 4. *Turritella ocoyana* Conrad s.s. Specimen No. 32.9 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 6 (Bremner) San Miguel Island; lower member of Temblor formation.

FIG. 5. *Turritella temblorensis* Weidey. Specimen No. 32.10 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 8 (Bremner) San Miguel Island; Vaqueros formation.

FIG. 6. *Turritella tritschi* Hertlein. Specimen No. 32.11 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 12 (Bremner) San Miguel Island; Vaqueros formation.

FIG. 7. *Turritella ocoyana* (Conrad) var. *bösei* (Hertlein and Jordan) Loel and Corey. Specimen No. 32.12 (S.B.M.N.H. Coll. Pal. Molusc.) from loc. 13 (Bremner) San Miguel Island; lower member of Temblor formation.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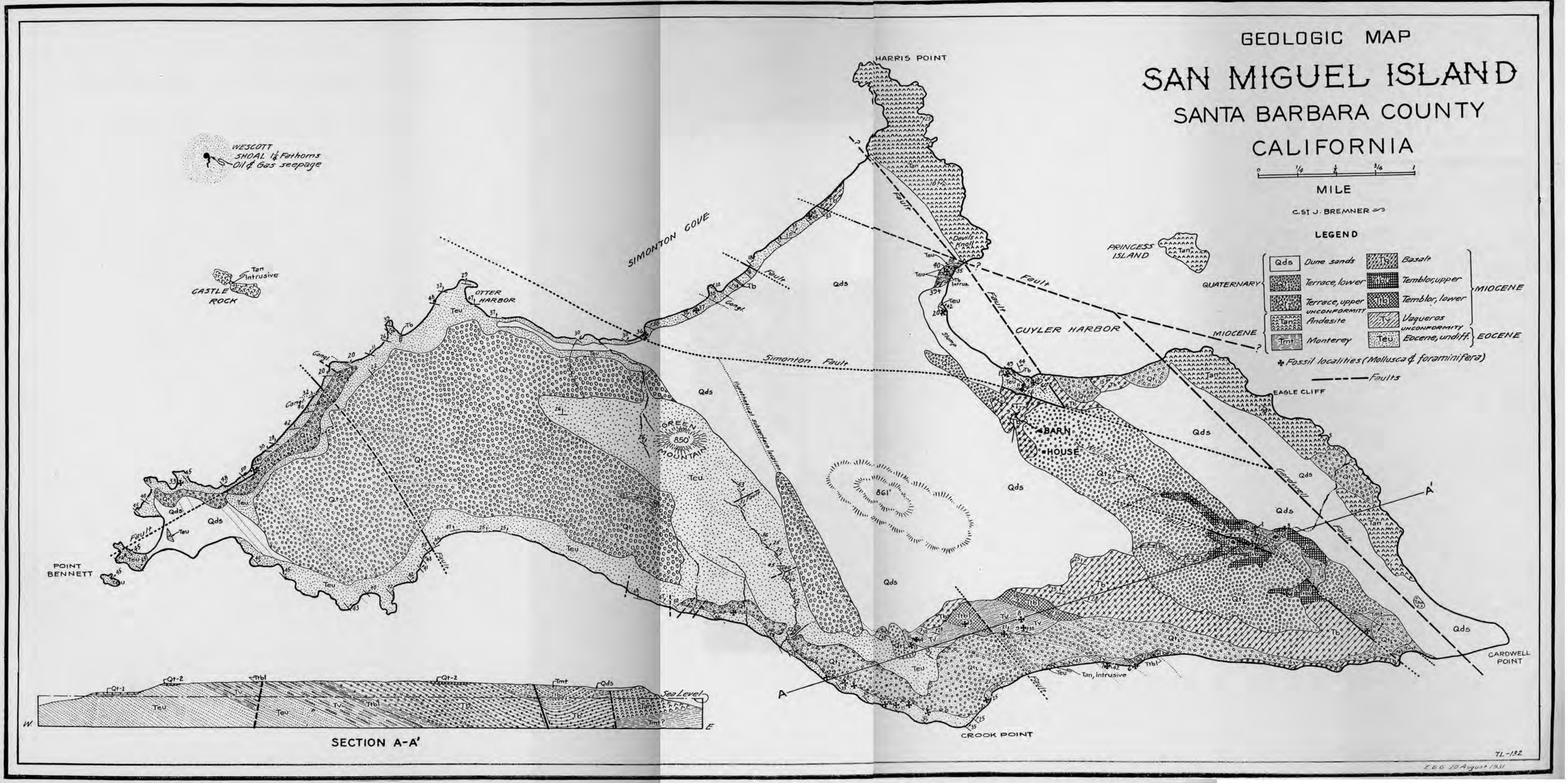
GEOLOGIC MAP
SAN MIGUEL ISLAND
SANTA BARBARA COUNTY
CALIFORNIA
0 1/4 1/2 3/4 1
MILE
C. St J. BREMNER
LEGEND
QUATERNARY
Qds Dune sands
Qt1 Terrace, lower
Qt2 Terrace, upper
UNCONFORMITY
MIOCENE
Tan Andesite
Tmt Monterey
Tb Basalt
Tbu Temblor, upper
Tbl Temblor, lower
Tv Vaqueros
UNCONFORMITY
MIOCENE
EOCENE
Teu Eocene, undiff.
Fossil localities (Mollusca & foraminifera)
Faults
HARRIS POINT
WESCOTT SHOAL 1¼ Fathoms
Oil & Gas seepage
CASTLE ROCK
Tan Intrusive
SIMONTON COVE
OTTER HARBOR
Simonton Fault
Fault
Devils Knoll
PRINCESS ISLAND
CUYLER HARBOR
EAGLE CLIFF
BARN
HOUSE
GREEN MOUNTAIN
850
861'
POINT BENNETT
CROOK POINT
CARDWELL POINT
Tan, Intrusive
A
A'
SECTION A-A'
W.
E.
Sea Level
TL-132
E.B.G. 20 August 1931